On the Underlying Representation of Creaky Vowels in Temalacayuca Popoloca*

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1 Introduction

1.1 *Aims of this paper* The aim of this paper is twofold. First, I demonstrate that the creaky vowel [V̰] in the speech of Temalacayuca Popoloca (henceforth TP) elders is either *V̄ʔ*, *V̀* or *V̀ʔ* underlyingly, as illustrated in (1)-(3). Second, I claim that younger speakers of TP have phonologized the creaky vowel as a tonal category, by losing processes in support of the opaque representations of creaky vowels in (1)-(3).

(1) [ˈīndą̰] *ī-nt**ā̀ʔ*** /PV-water/[1] 'water'
(2) [ˈką̰ttʲʰą̰o̰] *k**à**tʲhāwʔ* 'cornhusk'
(3) [ⁿdo̰ˈtánnà] *nt**ù**ʔtánà* 'my father'

The remainder of this section gives an overview of TP and the conventions of transcription (§1.2), the basic distributional facts about the creaky vowels (§1.3), previous accounts on them (§1.4) and the overall organization of this paper (§1.5)

1.2 *Overview of TP and transcription* Popoloca or *ngíwà* is an Otomanguean language from Popolocan branch spoken by approximately 20,000 people in the southern State of Puebla, Mexico. TP is spoken mainly in San Luis Temalacayuca, municipality of Tepanco de López by around 2,000 people normally over the age of 20.

Three principal Popoloca varieties are can be identified: TP, Tlacoyalco Popoloca and Southwestern Popoloca, which includes all topolects other than Temalacayuca and Tlacoyalco. However, there is little phonological variation that is the result of innovations rather than loss of contrast.

Data are drawn from my fieldnotes of TP, unless another source is indicated

Segments and their phonetic implementation are as follows: *a*[ɑ~a~ɛ] *e*[e̞] *i u*[u~o]; *t*[t̪] *tʲ*[t̪ʲ] *k k*^{w} *ʔ ts tʃ* [ʦ] *s ʃ* [ʂ] *h*[x~^{h}] *m n l r*[ɾ] *j w*. Plosives and affricates have a voiced allomorph after an *n*. Vowel nasality (*V Ṽ*) is contrastive for all vowels. Vowel length (*V VV*) is transcribed with two vowel letters. One of three level tones (*V́ V̄ V̀*, H M L or high mid low) is specified for each mora. Syllable structure is *(C)V(ʔ)* or *(C)V(ʔ)V*, where C may be a complex onset and only optionally in a few cases. Stress is fixed on the syllable with the penultimate mora; therefore, final syllable is stressed in VV# while the penultimate in VCV# (with phonetic lengthening of C) or VVCV#. The stress shifts due to suffixation; losing the stress, the lexical long vowel is contracted, accompanied with tone deletion and (in case of interrupted vowels) glottal stop resyllabification. Due to the prosodic word constraint which requires the phrase-initial word to be minimally bimoraic, monomoraic words in isolation have a prothetic *ī-* (glossed PV).

It should be noted that the tone is not transcribed phonetically for creaky vowels, given that there is no tonal contrast on them and the phonetic implementation varies. See §1.3.

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[1] Abbreviations are as follows: A pronominal set A, B pronominal set B, C pronominal set C, POSS Minor possessive pronominal set, AUG augmentative, HAB habitual, HON honorific, INS instrumental, NEG negative, PFV perfective, PV prothetic vowel, Q polar question. Compound boundaries are indicated by + but not always glossed.

1.3 *Creaky vowel in TP* In this subsection, I point out two distributional facts about creaky vowels in TP. First, TP creaky vowels are in complementary distribution with tautosyllabic preglottalized nasal or rearticulated vowel. Creaky vowels only occur with a short vowel, as in (4)-(6).[2] When there is a preglottalized nasal, as in (7), creaky vowels do not occur. Creaky vowels also do not occur on long vowels, where only rearticulated vowels are allowed (8), (9).

(4) [ˈīhn̰a̰] *ī-hnāʔ* /PV-mountain/ ‘mountain’
(5) [ˈs̰ā·o̰] *s̰āūʔ* ‘dew’
(6) [ˈtʃa̰s̰o̰] *tʃàʔs̰ū* ‘pretty’
(7) [ˈnīʔŋgō] *nīʔnkū* ‘church’
(8) [ˈtɨ̄ʔɨ̄] *t-īʔī̄*/HAB-be_called(C)/ ‘his name is’
(9) [ˈⁿdʒāʔàkō]~[ˈⁿdʒāa̰kō] *ntʃāʔàkū* ‘day’

No examples in which creaky vowels co-occur with tautosyllabic consonant preglottalization or vowel rearticulation are attested.[3] This distributional fact suggests the possibility that some of TP creaky vowels have their origin in consonantal glottal stop syllabified after a vowel. See §2.2 and §2.4.

Second, as already pointed out by Veerman-Leichsenring (1991:30), laryngealized vowels lack tonal contrast. Therefore, the second syllable of ‘oven’ (10) and the first syllable of ‘village, city’ (11) sound identical in terms of pitch, despite the different underlying representations.

(10) [ˈitɨtʲʰa̰] *i-tʲhāʔ* /PV-oven/ ‘oven’
(11) [ˈtʲʰa̰hn̰a̰] *tʲhàhnāʔ* ‘village, city’

Phonetically, a creaky vowel in Temalacayuca Popoloca is realized either as almost entirely creaky phonation with lowered pitch [a̰ɻ] or with a weak final glottal stop and a slightly higher pitch [aˀ˥]. [a̰ɻ] tends to occur on continuous di- or multisyllabic creaky vowel interrupted by a voiced consonant. Otherwise, [a̰ɻ] and [aˀ˥] are in free variation. Given the lack of tonal contrast, I will uniformly transcribe it as [a̰].

Finally, several Popoloca varieties have lost creaky vowels independently, including Almolonga, Coyotepec, Cuautempan and Zoyamazalco varieties (all Southwestern varieties), Tlacoyalco and the youngest speech of TP.

1.4 *Previous studies* On Metzontla variety, Veerman-Leichsenring (1991:30) analyzes that word-final creaky vowels are underlyingly *V̀ʔ* while word-medial ones are *V̀* due to Laryngealization Spread (§2.2). On Atzingo variety, Austin et al. (1995) postulate extra-low tone which largely corresponds to the creaky vowel in other varieties.

1.5 *Organization of this paper* The rest of this paper is organized as follows: §2 offers phonological and morphophonological evidence in favor of the opaque representation presented above. §3 describes how younger speakers have phonologized the creaky vowel as a tonal category. §4 lists some conclusions.

2 Creaky vowel as allophone of *V̄ʔ*, *V̀* or *V̀ʔ*

2.1 *Introduction* In this section, I argue that creaky vowels in TP have three underlying representations, namely, *V̄ʔ* (§2.2), *V̀* (§2.3) and *V̀ʔ* (§2.4). §2.5 is a summary of this section.

2.2 V̄ʔ In this section, I demonstrate that the morpheme-final creaky vowel is underlyingly *V̄ʔ*. §2.2.1 justifies postulating a coda glottal stop, while §2.2.2 argues in favor of postulating underlying mid tone.

2.2.1 *Coda glottal stop* Postulating a coda *ʔ* is supported by two pieces of evidence. First is the syllabification of *ʔ* in compound words. The first syllable of (12) has a creaky vowel while (13) does not have consonant preglottalization.

[2] *s̰āūʔ* ’dew’ is analyzed as hiatus. I do not discuss here the status of hiatus in TP.
[3] This constraint is also supported by the fact that when a suffix with a glottal stop deletes lexical creaky vowel/consonant preglottalization/vowel rearticulation. See §3.

(12) [ˈtạtʲtʲū] *t-āʔ+tʲū* /HAB-cross.A1/ ‘I cross’
(13) [ˈtãʔŋgí] *t-āʔ+nkí* /HAB-grow.A1/ ‘I grow’

In (12) and (13), one and the same morpheme *āʔ* is realized either as [ạ] or [ãʔ] depending on the following consonant. This supports that [V̰] originates in *ʔ* syllabified with the preceding vowel.

The other piece of evidence comes from the phonetic implementation. As pointed out in §1.3, the creaky vowels may be realized as weak final glottal stop [Vˀ]. They are phonetically distinguished from consonant postglottalization [ˀV] as in (14) or (15).

(14) [ˈtˀáŋgí] *t-ʔá+nkí* /HAB-grow.A3/ ‘he grows’
(15) [ˈxwˀíʃʃĩ̃] *w-h(ī)ʔí-ʃĩ̃* /PFV-come.A1-INS/ ‘I come from/by’

Thus, the morpheme-final creaky vowel has final glottal stop syllabified in the coda.

2.2.2 *Underlying M* Postulating underlying M is supported by three pieces of evidence. First, as already illustrated in (12) and (13), when a morpheme-final *ʔ* is resyllabified by compounding, the original syllable with creaky vowel is realized with mid tone. Additional examples are provided as (16) and (17).

(16) [ˈīnnḛ] *ī-nēʔ* /PV-HAB:eat.A1/ ‘I eat’
(17) [ˈnēʔnĩ̃ː] *nēʔ+nīī* /HAB:lick.A1/ ‘I lick’

Second, the clitic *á~a=* for polar question has tonally dissimilatory allomorphy. This proclitic has mid tone if the following tone is high or low, while it has high tone if the following tone is mid. See (18)-(20).

(18) [ˈákkõ̃] *á=kũ̄* /Q=eye.POSS3/ ‘(is it) his eye?’
(19) [ˈákkṍ̃] *á=kũ̄-ʔ* /Q=eye-POSS1/ ‘(is it) my eye?’
(20) [ˈākkò̰ã̃] *á=kṵ̀=a* /Q=eye.POSS2=2SG/ ‘(is it) your eye?’

In mid-toned (18) as well as creaky (19), the proclitic *á~a=* has high tone, while mid tone with low-toned (20). Therefore, the underlying tone cannot be low.

Third, set B pronouns for a subset of verbs and for the majority of nouns have three tonally conditioned allomorphs. The allomorphy of B1 *-(ʾ)(ʔ)nà* is formulated in (20) and illustrated in (21)-(24).

(20) *-ʔnà* /V̀CV̀_
-ʾʔnà /CV̀_
-ʾnà /elsewhere
(21) [kūtʃìˈᵑgạ̀ʔnà] *kūtʃìnkà-ʔnà* /pig.AUG-B1/ ‘my pig (pejorative)’
(22) [ˈtʃʰáʔnà] *tʃhấʔnà* < *tʃhầ-ʾʔnà* /child-B1/ ‘my child’
(23) [ˈhnánnà] *hnánà* < *hnā-ʾnà* /chili-B1/ ‘my chili pepper’
(24) [ˈhnánnà] *hnánà* < *hnāʔ-ʾnà* /mountain-B1/ ‘my mountain’

Crucially, the B1 allomorph for ‘my mountain’ is different from ‘my child’, which has lexical low tone. Therefore, the underlying tone for *hnāʔ* ‘mountain’ cannot be low.

In summary, morpheme-final creaky vowels have underlying mid tone and a glottal stop syllabified in the coda.

2.3 V̀ Morpheme-non-final creaky vowels before another creaky vowel have underlying low tone without a phonemic glottal stop. This is due to Laryngealization Spread (henceforth LS), a phonological rule formulated as (25).

(24) *V̀* > [V̰] /_C[V̰]$_{word}$

That is, within a word, a phonemic low tone is realized as laryngealized vowel. This rule is found in all extant

Popoloca varieties, and has also been formulated for the Metzontla variety in Veerman-Leichsenring (1991:30). Nakamoto (2016) formulated it as a phonological restriction *[V̀(C)V̰] (see also §3.2).

The rest of this section provides three lines of evidence in favor of postulating LS and underlying L tone. The first is *-ʔ(̀)* 'POSS1'. As already illustrated in (19) for *kɨ̃-ʔ* 'my eye', *-ʔ* 'POSS1' adds a final glottal stop. When the penultimate and contiguous non-final syllables have L tone (25), those syllables are realized with creaky vowels (26).

(25) [ⁿdʲàˈⁿdʲa̰kkʷɨ̃] *ntʲàntʲàkwɨ̃* 'his rib'
(26) [ⁿdʲa̰ˈⁿdʲa̰kkʷɨ̰̃] *ntʲàntʲàkwɨ̃-ʔ* /rib-POSS1/ 'my rib'

LS accounts for the non-final creaky vowels in (26). This type of creaky vowel can therefore be understood an allophone of L tone that surfaces in (25).

The second piece of evidence comes from morphemes with floating H tone. When a lexical word-final creaky vowel is replaced by H tone, lexical non-final creaky vowels (27) surface with L tone (28).

(27) [ˈxo̰xxa̰] *hùhāʔ* 'egg'
(28) [xòˈxánnà] *hùhánà* < *hùhā(ʔ)-ˊnà*/egg-B1/ 'my egg'

LS also explains the creaky vowel on the first syllable in (27). The first syllable is realized with allophonic L in (28) due to the loss of creaky vowel on the second syllable which triggered LS in (27).

The third piece of evidence is tonally dissimilatory alomorphy (cf. §2.2). Compare (29) and (30).

(29) [āˈxo̰xxa̰] *ā=hùhāʔ* '(is it) egg?'
(30) [áʂo̰ˈʂāˑo̰] *á=ʂūʔ+ʂāūʔ* /Q=stone+dew/ '(is it) glass/bottle?'

In (29), *á~ā=* has M as the following tone is underlyingly L, while in (30) the proclitic has H tone before the underlying M on the first component of the compound word.

In summary, morpheme-non-final creaky vowels before another creaky vowel are allophones of L. It is due to Laryngealization Spread, a phonological rule by which low tones to the left of a creaky vowel within a word are realized with creaky vowel.

2.4 V̀ʔ Two types of creaky vowels have underlying *V̀ʔ*. §2.4.1 shows lexical morpheme-penultimate creaky vowel before final non-creaky vowel. §2.4.2 demonstrates that stem alternant *ʔC* from historical *Cʔ can cause a creaky vowel too.

2.4.1 *Penultimate creaky vowel before final non-creaky vowel* Morpheme-penultimate creaky vowels before non-creaky vowel may be short, as in (31), or long, as in (32).

(31) [āˈᵑga̰hnī] *ā=nkàʔhni* '(is it) sky?'
(32)=(9) [ˈⁿdʒāʔàkō]~[ˈⁿdʒāa̰kō] *ntʃāʔàkū* 'day'

In (31), the dissimilatory allomorphy (cf. §2.2) indicates that the underlying tone of the creaky vowel is L. In (32), the creaky vowel is in free variation with an interrupted vowel with a L-toned second portion. Furthermore, when the long vowel in (32) is contracted by suffixation, M on the first portion is deleted and a L-toned creaky vowel remains.

(33) [ānˈdʒa̰ˈkónnà] *ā=ntʃàʔkúnà* < *ā=ntʃ(ā)ʔàkū-ˊnà* /Q=day-B1/ '(is it) my day?'

In all cases, a penultimate creaky vowel before final non-creaky vowel is underlyingly L-toned, while the source of the creaky vowel should be accounted for separately; I postulate a consonantal glottal stop.

2.4.2 *Stem allomorph* ʔC <**Cʔ* Proto-Popoloca *Cʔ has *C~ʔC* as its TP reflex. The allomorph *C* appears when the preceding morpheme has H or M, as in (34), while *ʔC* when L, as in (35), causing the first element of the compound to have creaky vowel; (36) is the cognate in Metzontla variety.

(34) [ʃĩˈtánnà] *ʃĩtánà* < *ʃĩ+ta-´nà* /man+father-B1/ ‘my father’
(35) [ⁿdo̰ˈtánnà] *ntùʔtánà* < *ntù+ʔta-´nà* /man.HON+father-B1/ ‘my (honorable) father’
(36) *tʔá-* ‘father’ (Metzontla Popoloca; Veerman-Leichsenring 1991:481)

In (34), ‘father’ is preceded by a H-toned morpheme *ʃĩ* ‘man’ and does not have a glottal stop before *t*, while in (35) ‘father’ is preceded by a L-toned morpheme *ntù* ‘man.HON’ and has a glottal stop before *t*. On the other hand, in (36) from Metzontla, ‘father’ always has a glottal stop after *t*.

One might think that metathesized *ʔ* disappeared in (34) because there is no tautosyllabic *ʔt* sequence. However, it is not true. (37) and (38) from Proto-Popoloca *ntʔ shows that the occurrence of *ʔ* is conditioned by tone and thus *ʔ* is syllabified with the following *nt*. (39) is the Metzontla cognate.

(37) [ʃĩˈⁿdínnà] *ʃĩntínà* < *ʃĩ+nti-´nà* /man+grandchild-B1/ ‘my grandchild’
(38) [ⁿdòˈʔⁿdínnà] *ntùʔntínà* < *ntù+ʔntí-´nà* /man.HON+grandchild-B1/ ‘my (honorable) grandchild’
(39) *ngaʔsándʔí* ‘grandchild’ (Metzontla Popoloca; Veerman-Leichsenring 1991:463)

In (37), the stem allomorph *nti* does not have a glottal stop, while (38) does. Given that *ʔ* is syllabified with the following consonant in (38), *ntù* ‘man.HON’ is realized with phonetic L tone. On the other hand, Metzontla *ngaʔsándʔí* (39) has postglottalization after *nd*. Additional cognates include TP *ntʲàʔtʃwə̃-* and Metzontla (Veerman-Leichsenring 1991:459) *ndʲàtʃʔũ̃* ‘back’.

In summary, *V̀ʔ* should be postulated for two kinds of creaky vowels. The first is morpheme-penultimate creaky vowel before final non-creaky vowel (§2.4.1) and the second is lexically L-toned morpheme compounded as the first element with stem allomorph *ʔC* in which C is an obstruent as the second element (§2.4.2).

2.5 *Summary* In this section, I have presented evidence that a creaky vowel in TP may underlyingly be *V̄ʔ*, *V̀* or *V̀ʔ*. These representations are partially predictable from (i) position (i.e. morpheme-final or non-final), (ii) morphological composition (i.e. simplex or complex) and in some cases (iii) etymological information (morphemes with stem allomorph *ʔC* <*Cʔ, in addition to L on the first element of compound). This representation is abstract, given that the three underlying forms are postulated for the same phonetic (but not phonemic) pattern for the sake of analytical simplicity (cf. Hyman 1970).

3 Phonologization of *V̰*

3.1 *Introduction* In this section, I show that younger speakers of TP have completed the phonologization of *V̰* as a “fourth tone” through three stages, namely, the existence of (morpho)phonological processes which refer to phonetic [V̰] rather than the underlying representations (§3.2), phonologization of [V̰] and [VˀV] as phonation categories (§3.3) and V̰ as a tonal category (§3.4). §3.5 is a summary of this section.

3.2 *Processes which refer to creaky vowel* In this section, I demonstrate that the elder speech of TP already has two processes which refer to the phonetic creaky vowel rather than the underlying representations. The first is Laryngealization Spread (§2.3). (40) and (41) demonstrate that the trigger of LS can underlyingly be *V̄ʔ* (third syllable of (40)), *V̀* (second syllable of (40)) or *V̀ʔ* (second syllable of (41)).

(40)=(26) [ⁿdʲa̰ˈⁿdʲa̰kkʷḭ̃] *ntʲàntʲàkwĩ̄-ʔ* /rib-POSS1/ ‘my rib’
(41) [ʂa̰ˈna̰hnī] *ʂànàʔhnī* < *ʂə̀+nàʔhnī* /alcoholic_drink+Spanish/ ‘aguardiente’

The second is Tone Mutation (henceforth TM), by which the lexical L in the first component of a certain type of compound nouns changes into M before a creaky vowel (Nakamoto 2016). (42)-(44) demonstrate that the trigger of TM also can underlyingly be *V̄ʔ* (42), *V̀* (43) or *V̀ʔ* (44).

(42) [ˈkāhma̰] *kāhmāʔ* < *kà+hmāʔ* /plant+bean/ ‘bean plant’
(43) [tʲūˈnõ̰ːwã̰] *tʲūnùāʔ* < *tʲù+nùāʔ* /fruit+avocado/ ‘avocado fruit’
(44) [tʃʰēˈna̰hnī] *tʃhēnàʔhnī* < *tʃə̀+nàʔhnī* /cactus_fruit+Spanish/ ‘dragon fruit’

TM indicates the compound boundary between the two components. TM is not found with lexicalized compounds where the boundary is not recognized by the speaker.

Thus, LS and TM treat *V̄ʔ*, *V̀* and *V̀ʔ* in the same manner and they share the surface realization (creaky vowel). It may have been the motivation to phonologize the creaky vowel.

3.3 *Phonologization as a phonation category* In this section, I argue that the elder speech of TP has already phonologized the creaky vowel [V̰] as a phonation category together with the interrupted vowel [VˀV] before phonologizing [V̰] as a tonal category. It is demonstrated by the different behavior of [V̰] and [VˀV] from preglottalized sonorants [ʔC] with Set B person suffixes. Set B person suffixes, which have allophones with a glottal stop as shown in (20), delete the preceding glottal stop in a creaky vowel or an interrupted vowel but not in a preglottalized sonorant. See (45)-(47).

(45) [ˈⁿdánnà] *ntāʔ-ˊnà* /water-B1/ 'my water'
(46) [ˈtʃánnà] *tʃāʔà-ˊnà* /flea-B1/ 'my flea'
(47) [kūléˈʔwánnà] *kūléʔwā-ˊnà* /sparrow-B1/'my sparrow'

In (45) and (46), the lexical glottal stop is deleted by a Set B person suffix, while it is intact in (47). On that basis, *V̰ʔ* and *VʔV* can be argued to form a natural class as phonation categories. This difference of behavior is contrasted with *-ʔa~ʔi* NEG which deletes all three types of tautosyllabic *ʔ*. See (48)-(50).

(48) [ˈnɛ̃ʔã̄] *nē(ʔ)-ʔā* /HAB-eat.A1-NEG/'I don't eat'
(49) [ˈtíʔā] *t-(ī?)í-ʔā* /HAB-drink.A1-NEG/ 'I don't drink'
(50) [tāˈᵑgíʔā] *t-ā(ʔ)nkí-ʔa* /HAB-grow.A1-NEG/ 'I don't grow'

-ʔa~ʔi NEG deletes *ʔ* in *V̰ʔ* (48), *VʔV* (49) as well as *ʔC* (50), while Set B suffixes only target *ʔ* in *V̰ʔ* and *VʔV*. It suggests that the phonologization of [V̰] and [VˀV] as phonation categories is only partial.

3.4 *Creaky vowel as a tonal category* Some younger speakers of TP reanalyzed the creaky vowels in citation form as underlyingly creaky. Compare (51) and (52).

(51) [xo̰ˈxánnà] *hṵhánà* < *hṵhą̰-ˊnà* /egg-B1/ 'my egg' (younger speech)
(52)=(28) [xòˈxánnà] *hùhánà* < *hùhā(ʔ)-ˊnà* /egg-B1/ 'my egg' (elder speech)

In (51), the creaky vowel in isolation (first syllable) remains creaky after the suffixation of B1. In (52) from elder speech, as already discussed in §2.3, the underlying L is revealed when the LS-triggering word-final creaky vowel is removed by B1. It suggests that younger speakers phonologized creaky vowel as a tonal category, abandoning the non-final opaque contrast between different underlying tone and glottal stop.

On the other hand, LS is maintained with *-ʔ* POSS1, as shown in (53). However, LS should be reformulated according to the new representation in (54).

(53) [ⁿdʲą̰ˈⁿdʲą̰kkʷḭ̃] *ntʲą̰ntʲą̰kwḭ̃* /rib:POSS1/ 'my rib'
(54) *V̀* > *V̰* /_ *V̰*

At this stage, we can see that the underlying tones and a glottal stop merged into [V̰], that is, the phonologization of a fourth tone was completed among younger speakers.

3.5 *Summary* Stages of this phonologization can be postulated in a relative chronology; see (55).

(55) Coda *ʔ
> Rise of abstractness on representing *ʔ* (Laryngealization Spread, *Cʔ metathesis, compounding)
> Rise of phonation contrast ([V̰] and [VˀV])
> Loss of abstract contrast

4 Conclusions

In conclusion, two different states of creaky vowels in TP show a tonogenesis in process. For elder speakers, [V̰] is derived from three underlying representations, while for younger speakers *V̰* entered into a paradigmatic relationship with other three tones (H, M and L), through the loss of abstract tonal contrast on non-final syllables (§3.4).

On one hand, the analysis of TP elder speech is basically in line with Veerman-Leichsenring's (1991:30) analysis of Metzontla variety in postulating three level tones and a glottal stop. However, I pointed out that word-final creaky vowels are underlyingly *V̄ʔ* (and not *V̀ʔ*) (§2.2), in addition to that *V̀ʔ* is another source of creaky vowel (§2.4). On the other hand, younger speakers of TP have a fourth tone, as in Atzingo variety (Austin et al. 1995). However, the fourth tone in TP took a different route from that of Atzingo. In Atzingo, as well as in TP, the fourth (extra-low) tone originates in *[V̰]. Unlike TP, the fourth tone in Atzingo comes from the loss of phonotactic constraint on two tautosyllabic phonetic patterns originated in *ʔ, in particular tautosyllabic preglottalization and creaky vowel, which probably comes from the change of phonetic implementation of *[V̰] to [V̏]. See (56) for an illustration.

(56) [ˈɪ̄ʔnò] < *[ˈɪn̰n̰o̰] < *[ˈɪnno̰] 'string' (Austin et al. 1995:40, reconstructions mine)

In (56), the word-final vowel laryngealization in Proto-Popoloca *[ˈɪnno̰] extended to the preceding sonorant in Pre-Atzingo *[ˈɪn̰n̰o̰], which in turn split into two different existing categories: sonorant preglottalization and the extra-low tone.

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